Mission Operations Risk Management

Analyses of recent major aerospace mishaps have identified human and organizational factors as frequent contributing causes, including failures of risk perception, risk communication, contingency planning, decision making, and drift from safe practices. Risk management is necessary during both mission planning and in real-time mission operations. Observations, interviews, and surveys have been used to identify human and organizational risks during planning and operations for unmanned deep-space missions (e.g., Mars Exploration Rover) and crewed missions involving the ISS, MIR, and space shuttles. Advanced concepts and tools will be developed to support risk management in future exploration missions to the Moon and Mars.

Background

Risk management depends on the perception and recognition of sources of risk in all phases of a mission. Analyses of high-reliability organizations have identified generic risk factors; others are specific to NASA operations. Three conditions that can cause mission and safety failures are finite resources, task and organizational uncertainty, and changing, dynamic environments. Specific features common to all high-risk environments also include mission and systems complexity and distributed teams (engaged in both design and operations). Both features require huge amounts of coordination and information sharing, which are potential sources of risk.

Human and organizational risks can be analyzed at several levels: the organization, the team, and the individual. Risk factors at the organizational level include organizational culture, schedule, cost, and pressure from various governmental bodies. Values and attitudes toward safety and mission goals, blame-free reporting procedures, organizational flexibility, and open communication channels that support voicing of minority opinions help to manage known organizational risks. International partners entail risks associated with different levels and types of risk tolerance, lines of authority, added procedures, and lack of defined roles and responsibilities. Even within organizations, goal and role conflicts can exist between scientists and engineers, between different levels of management, and between teams.

Risks at the individual level have been most thoroughly studied: These include training, workload and fatigue, job satisfaction, morale and attrition. Individual level factors can percolate up to influence team and organizational level risks just as organizational decisions can influence the capability of individuals to function effectively.

Research Overview

Organizational risk models were developed by combining theories from the organizational and team literatures with insights derived from observations from NASA work domains. Surveys, observations, and interviews have been collected from several NASA sites, including JSC Mission Control, JSC Vehicle Integrated Performance and Environmental Resources (VIPER) Team, and JPL conceptual design teams (e.g., Team X).

One area this group has studied in detail is distributed teams. Distributed teams entail major requirements for information sharing in support of collaboration and coordination. Individuals in distributed teams, whether engaged in mission design or operations, may lack the big picture concerning systems or missions; information updates may be problematic, and misunderstandings may arise due to false

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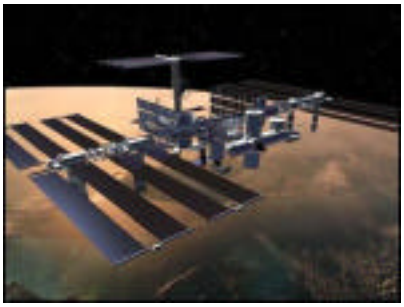
assumptions. Organizational barriers may impede timely and complete information flow across teams, especially between contractors, international partners, and government organizations.

Based on these sources of data, an organizational risk ontology (relational and taxonomic database) has been developed which has fed a risk tool suite for system design. The ontology includes mission objectives, mission features, threats, risks (likelihoods and consequences), and mitigations. This database is a prototype of what would be a useful, searchable tool for project managers and mission designers.

Other systems, tools and procedures are needed to support knowledge sharing and appropriate decision making across time and space. During design processes, distributed teams may assign different meanings to terms or use different methods, differences that may not be obvious. Multiyear projects require documentation of assumptions and decision rationales held by original mission designers so that individuals engaged in mission operations years later can understand why systems and procedures were designed as they were. Exceptions and revised plans must be updated regularly during mission operations and must be accessible. Shift-handovers are routine, but potential sources of risk, especially in off-nominal situations.



Risk surveys can also act as tools to measure safety climate and detect when an organization is drifting too close to the boundaries of safe practices. Knowledge management tools can provide support for real-time decisions about production and safety tradeoffs.

Risk management strategies have been identified in several high-reliability organizations. Recommendations will be developed and assessed for application in NASA environments.

Relevance to Exploration Systems

Conceptual, methodological and operational gaps exist between mission planners, engineers, controllers, scientists and managers, gaps which are exacerbated in remote operations. Research will contribute to ASCT goals by developing and assessing tools and methods to control risks during operation of complex human and automated systems in manned space missions. Data will feed into system analysis and design of advanced operational concepts for exploration systems. Prototypes will contribute to reliable and responsive ground operations systems, with emphasis on real-time risk assessment, communication, and risk-informed decision making.

H&RT Program Elements:

This research capability supports the following H&RT program /elements:

Advanced Studies Concepts and Tools, Advanced Space Operations

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